EXHIBIT F

Marcellin Fire Investigation

1.0 Introduction

This report summarizes my investigation of a fire that occurred on January 24, 2020 at 192 Bells Brook Road in Genesee, New York at the residence of Carol Marcellin and Charles Hollowell. A Hewlett Packard (HPI) computer was with the evidence collected from the fire scene by Fire Research and Technology (FRT) of Sodus Point, New York. An allegation has been made that the computer's battery pack failed and was the cause of the fire. My investigation deals with the electrical engineering aspects of that issue. I was asked to write this report by Coughlin Betke LLP who represents HPI in a legal matter resulting from the fire.

I performed the following tasks in conducting my investigation.

1. Attended an evidence examination at FRT on October 27, 2000.
2. Examined and had xrays taken of an exemplar HPI computer
3. Reviewed the computer component CT scans

I also reviewed the following documents.

1. The August 2, 2023 deposition of Lee Atkinson
2. The August 7, 2024 deposition of David PiPho
3. The fire scene photographs of Gregg Gorbett
4. The October 14, 2024 Reports of Fire Research & Technology
5. The October 14, 2024 Report of Steve Martin
6. The HPI discovery documents HP00001-HP01438
7. The computer and battery pack schematics in the HPI production
8. Additional documents sent by email on February 21, 2024
9. The data sheets for the BQ20Z70, S8264, BQ29330
10. The July 7, 2023 and July 9, 2024 depositions of Carol Marcellin

2.0 Brief Description of the Fire

The fire occurred in the evening of Jan 24, 2020. The computer alleged to have caused the fire (the subject computer) was opened and located on a shelf in a room where the fire apparently originated. Mrs. Marcellin testified that she was awakened by a smoke alarm around 4 AM. She silenced the alarm and could see a glow from the room where the computer was located. She gets a fire extinguisher from the kitchen and attempts to fight the fire. She was unable to fight the fire.

According to her testimony, Carol Marcellin lived with Charles Hollowell and they shared a bedroom. Mr. Hollowell required a wheelchair. Carol Marcellin woke him up and he tried to get into his wheelchair. She returned to the room to help him, but he had fallen, and she was unable to lift him. She left and tried to call for help, which she ultimately did, using the "On-Star" feature from her car. She had to drive away from the house to get a signal. Mr. Hollowell was unable to get out of the house himself and died as a result of the fire.

.

The Allegany Fire Service (AFS) Investigation form FI 20-003i9 included this language.

> *"Based upon our observation and ruling out other probable causes it is our hypothesis that the cause of the fire is the HPI notebook. The HPI notebook battery or components near the battery caused the battery to overheat and explode, sending sparks and flammable material that ignited light weight fuels in the office area of the computer cabinet or closet."*

It is unclear as to what additional efforts AFS undertook to determine the cause of the fire beyond stating a hypothesis. Nothing in the AFS material indicates that they considered the effects of ambient heat exposure on the battery cells.

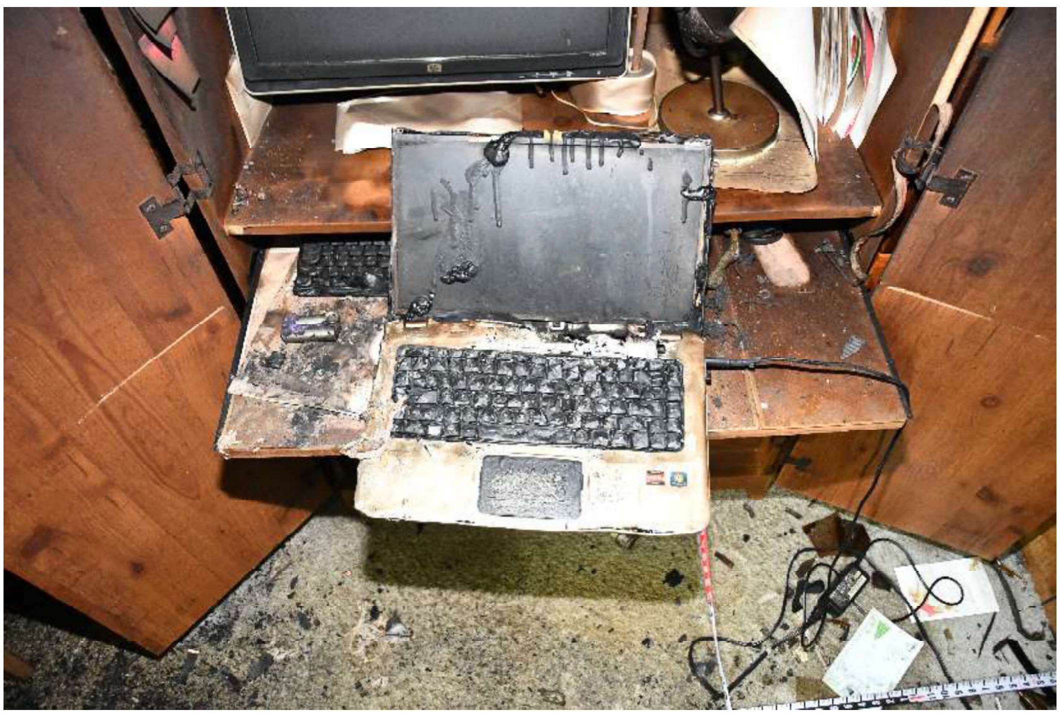

Figure 1. Photo of (alleged) subject computer at the fire scene.

3.0 Description of the original HPI components

The computer consists of three related computer parts typically sold together. These are the computer itself, the battery pack, and the AC adapter. These will be described in the following sections.

3.1 Computer

The computer is a model DV6-3210US. A photo of the general appearance of the top view of a sample of this computer is shown in Figure 2. The bottom of the computer is shown in Figure 3 in which the location of the battery pack is indicated by the dotted red line.

Figure 2. Photo of DV6 Computer Front View

Figure 3. Bottom view of DV6 Computer

(Battery is removed, dotted line shows battery compartment)

The battery compartment is shown in Figure 4. The computer operates with a 6-cell lithium-ion battery pack and can also be powered from an AC adapter. The power sources will be described in subsequent discussions.

Figure 4. Battery Compartment

3.2 Computer Safety Features

The computer meets Underwriter's Laboratory (UL) standard 60950 – Information Technology Equipment – Safety Part 1: General Requirements. The UL charter focuses on assuring that the product does not present any fire or shock hazards. The testing is accomplished using a "CB" scheme. CB stands for certification body and is an international system for acceptance of test reports. The UL Testing includes tests for the following:

- Protection against causing an electric shock
- Protections against producing temperature extremes, mechanical hazards, fire hazards
- Components must meet safety standards or be tested for their operating conditions
- Abnormal operating conditions including key component failures are tested

Some safety features incorporated by HPI are:

- Adapter input power processed separately from other power circuits
- Each subsystem (display, processor, drives) has independent dc power supply circuits
- Each supply circuit has independent protection against over-current, over-voltage, over-temperature
- Computer processor temperature measurement and temperature limiting
- Shut down on over-temperature
- Temperature measurement of battery pack

There have not been any other lawsuits alleging a fire starting from this model computer.

3.3 *The battery pack*

Figure 5 shows the battery pack when it is removed from the computer.

Figure 5. Battery pack removed from computer

The battery pack consists of 6 cylindrical Lithium-ion batteries in metal containers. A photograph of a typical DV6 HPI battery pack is shown in Figure 6 with the outer plastic housing removed. The batteries (cells) are 18 mm in diameter (about 0.7 inches) and 65 mm long (about 2.5 inches). This battery type is usually referred to as an “18650”, because of its dimensions. The battery pack in the subject computer had 6 of these “18650” cells.

Figure 6. Interior of HPI battery pack showing cells and battery management circuit board.

In addition to cells there is a circuit board, usually called the battery management unit or battery management system. The abbreviation BMU will be used in this report to refer to the battery management unit. The BMU also has a connector which provides the electrical connection to the notebook and allows the battery to power the notebook. Figure 7 shows a close-up of the BMU circuit board with a dotted red line around the connector.

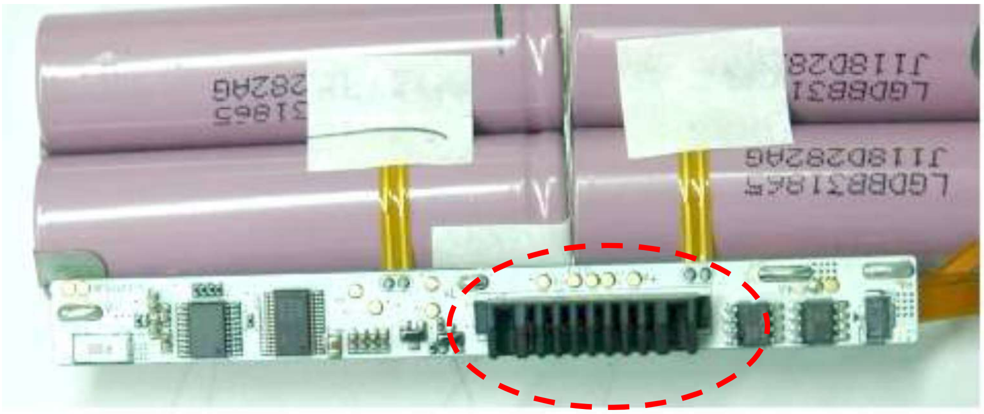

Figure 7. The battery management unit (BMU) circuit board.

The cells in the battery pack are charged using power supplied by the notebook when the notebook is connected to the AC/DC adapter and the adapter is plugged into a wall receptacle. DC power is supplied to the notebook by the adapter and is also used for charging the battery pack. The battery pack supplies DC power to the notebook when the notebook is not connected to an adapter.

Once a battery pack is plugged into the computer, the battery pack and the notebook communicate using electrical signals provided by the connector shown in Figure 7. Some of the signals use a digital communication function and get information about the following functions of the battery pack:

1. The state of charge of the battery (e.g. 60% charge, 80% charge)
2. The battery charge current (e.g. 1 Ampere).
3. The computer can request information about the battery voltage (e.g. 11 Volts)

The BMU has 3 basic functions:

1. The fuel gauge (how much charge is in the battery)
2. Control of charge and discharge
3. Safety functions

3.4 Battery Pack Safety Features

Some of the safety functions require communication with the notebook. The functions have physical electronic devices associated with them and they are shown in Figure 8.

The integrated circuits (commonly called "chips") are shown with a "U" designation (e.g. U2). U1 is not visible, because it is on the bottom of the board. The designation U, followed by a number, is standard for integrated circuit numbers on a schematic, which is an electrical connection diagram.

The 1st level safety functions are carried out by U3. These include things like turning ON and OFF transistors that are for charging or discharging the battery pack. This prevents over-charging or over-discharging the battery. U3 also keeps track of how much charge is in the battery. This is usually called a "fuel gauge" function.

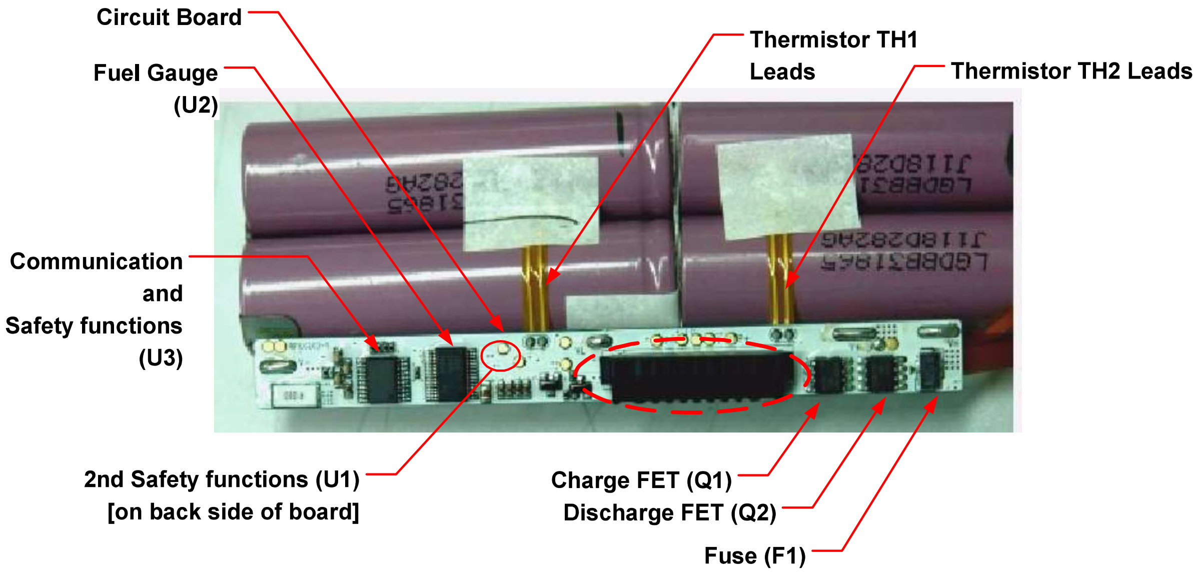

Figure 8. Location of parts on the BMU circuit board

The 2nd Level safety functions are carried out by U1. One of those features is over-charge protection. U1 can operate an electronic fuse on the BMU board. That is like a household circuit breaker. Once it is "blown" the pack is permanently disabled and cannot be used.

Cell balancing is carried out by U2. Cell balancing assures that all the cells operate at equal charge levels over the life of the pack.

There are 3 thermistors on the circuit board. Thermistors are components that measure temperature. Two thermistors, called TH1 and TH2, are used to measure battery temperatures. The leads for TH1 and TH2 are indicated in Figure 8. Thermistor TH3 is located between the C and D-FETs. TH3 is not visible in the picture because it is on the back side of the circuit board.

The battery pack was tested according to 2 standards. First is the pack itself, which undergoes testing (again in a CB scheme) according to UL 60950 Information Technology Equipment – Safety Part 1: General Requirements. The cells themselves are tested according to UL2054 Certification of Lithium-ion Battery, which is an additional set of specific electrical tests. The cells are also subject to testing according to UL1642 during which they must safely survive crush, impact and heating tests.

There are some physical features of the pack construction that provide safety functions. These are called out in the battery pack specification, Bates number HP01366. A few of these are:

1. Temperature sensing of the battery pack. This is done by thermistors TH1 and TH2.
2. Measurement of the individual cell voltages. Or, in the case of cells in parallel, measuring the voltages of the cell pairs. This is done by connecting all the cell terminals to the BMU as shown in Figure 9 below.

3. HPI requires the use of metal “Battery Straps” instead of wires to connect the cells to the BMU circuit board. The connections made by the straps are shown in Figure 9. Figure 10 shows the straps on a typical HPI battery pack.

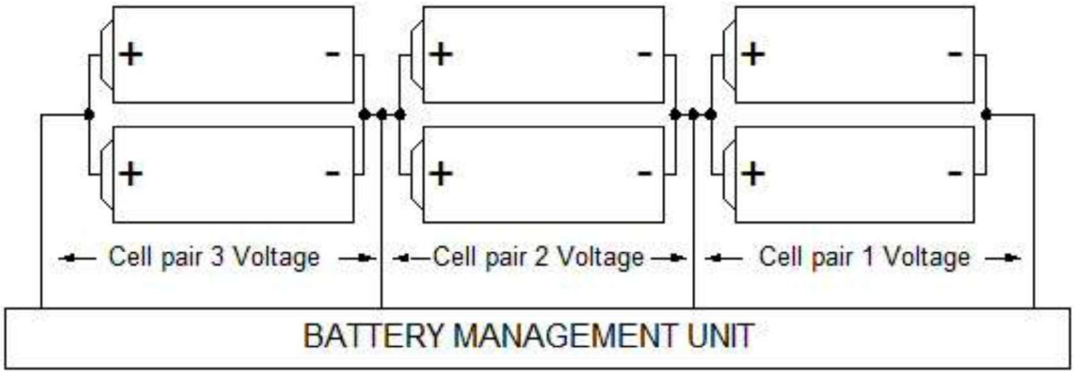

Figure 9. Arrangement for measuring the voltages of each pair of cells

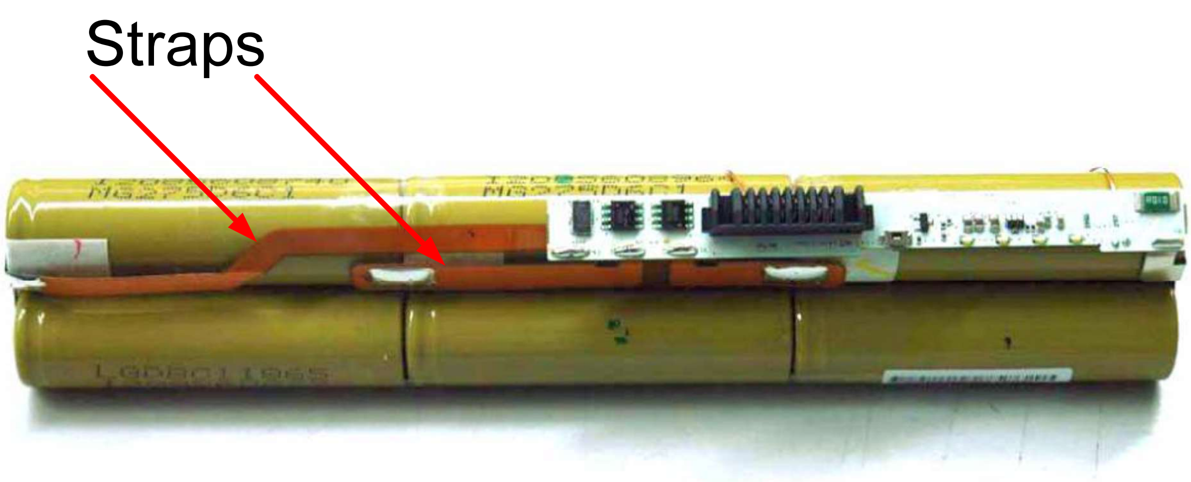

Figure 10. Straps on a typical HPI battery pack

3.5 Lithium-Ion Batteries and Heat Exposure

Heat exposure from a source outside the computer can induce a condition in Lithium-Ion cells (the 18650's) called "thermal runaway". Thermal runaway is a progressive condition in which heat and pressure build up inside the cell. If the pressure is high enough a safety vent in the cell will rupture and release internal cell pressure. In some cases, the vent may become blocked, and the cell will explode. This releases hot metal and gas and can ignite material external to the battery pack.

Thermal runaway can be induced in cells when they are exposed to excess external temperatures. Thermal runaway results in pressure buildup inside the cell and can also cause expulsion of the rolled-up cell contents. Photographs of the room and area around the computer taken after the fire demonstrate that the subject computer was exposed to external heat.

3.6 The AC Adapter

The AC adapter converts household electric power to direct current (DC) for use by the computer. That power will either run the computer if there is no battery, charge the battery and operate the computer simultaneously, or just charge the battery if the computer is off. The AC adapter was separately tested according to UL60950.

3.7 AC Adapter Safety Features

Some of the adapter's safety features are:

1. DC current limiting
2. An automatic shut-down feature if the DC output is overloaded
3. An input fuse on the AC (alternating current) input side
4. Operation over a wide AC voltage range of 90-250 Volt

The top and bottom views of the AC Adapter are shown in Figures 11 and 12 respectively.

Figure 11 Top view of AC adapter

Figure 12. Bottom view of AC adapter

The AC adapter is UL listed and has been recognized by worldwide agencies. The safety regulatory markings on the AC adapter include markings from Germany, Argentina, the European Union (CE mark), Mexico (NOM) United States (UL), Japan (PSE) and South Korea (KETI).

4.0 Laboratory Evidence Examination

I attended an evidence examination on October 7, 2020 at Fire Research and Technology (FRT) in Sodus Point, New York. My observations are presented in the following discussions.

4.1 Evidence Item # 6, Computer from desk area

This computer was recovered from the desk area (where plaintiff has alleged the fire began). It is a model DV6-3210US HPI Pavilion. Photos of the top and bottom of the (alleged) subject computer are shown in Figures 13 and 14 respectively.

Figure 13. Top View of subject computer

Figure 14. Bottom view of subject computer

An x-ray of the computer is shown in Figure 15. The only apparent internal damage to the computer was that caused by two of the battery cells. Other than that, the notebook computer is not damaged in the way that would be expected if it was the cause of the fire.

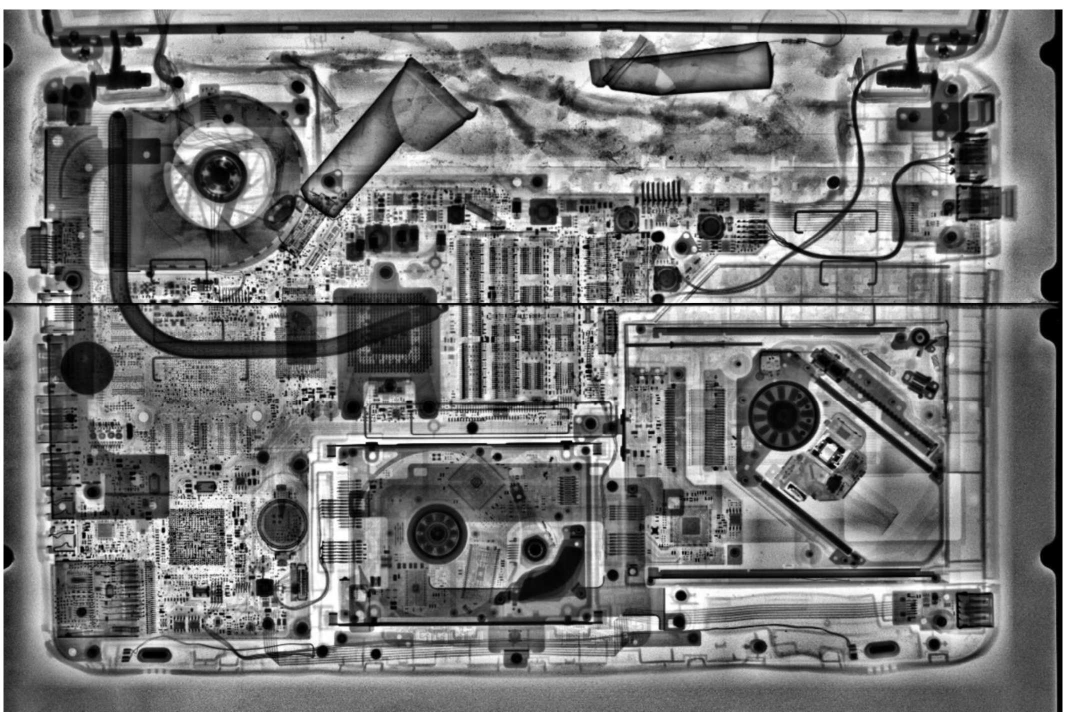

Figure 15. X-ray image of subject computer

The area of most interest was the battery pack because of thermal damage to the cells. By itself the damage does not indicate the battery was the cause of the fire. Thermal damage to the battery can be caused by heat exposure from the fire. This was pointed out in section 3.5.

4.2 Subject battery pack was not made by HPI

The BMU circuit board was recovered. There are several notable features which are discussed in the following sections that all show that the battery pack in the computer was not made for HPI and was not the original battery pack. This is not disputed by plaintiff's expert Dr. Martin.

4.2.1 The BMU uses wires

Figure 16 shows 2 holes on the left and right ends of the circuit board. Those holes have a shiny ring-shaped area around them. That is from solder joints used to connect a wire to the cells in the battery assembly. The use of wires to connect the BMU to the cells is prohibited by the HPI battery pack specification. It is also inconsistent with other HPI battery packs I have examined.

4.2.2 The BMU does not measure individual cell voltages

Only the voltages at the ends of the cell stack (the assembly of all 6 cells) can be measured since there are only two wires connected to the cells. The individual cell voltages cannot be measured (as shown in Figure 9) with just two wires. The HPI battery pack specification requires that the individual cell voltages of the pack be measured.

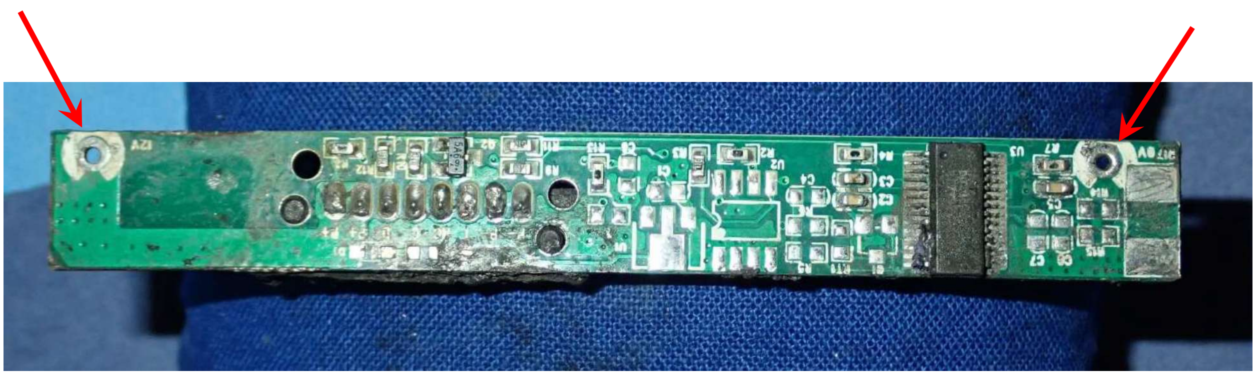

Figure 16. BMU from subject computer after cleaning. Arrows indicate solder pads for wires to cells.

4.2.3 The battery cells are not original to the HPI battery pack

Each battery manufacturer has a specific hole pattern on the top cap of the cell. The cell caps for the subject battery (left) and the LG battery (right) that was shipped with the HPI notebook are shown in Figure 17 below. The subject cells have 5 vent holes whereas the original (LG) cells have 4 holes. HP00481 indicates the original pack was made by LG, with LG cells. The subject battery pack was not the one shipped by HPI.

Figure 17. Subject cell cap(left) and LG cell cap(right)

4.2.4 **Labeling**

A label on the BMU circuit board was visible after the board was cleaned as shown in Figure 18. That label reads “20150429”. This arrangement is typical of date codes and indicates the battery pack was made in 2015 and indicates that it was made 5 years after the computer was manufactured in 2010. It could not have been the original pack nor the pack sold with the notebook when it was sold to Ms. Marcellin.

The label also reads DV4 and has no DV6 reference, indicating this is not a genuine HPI label at all.

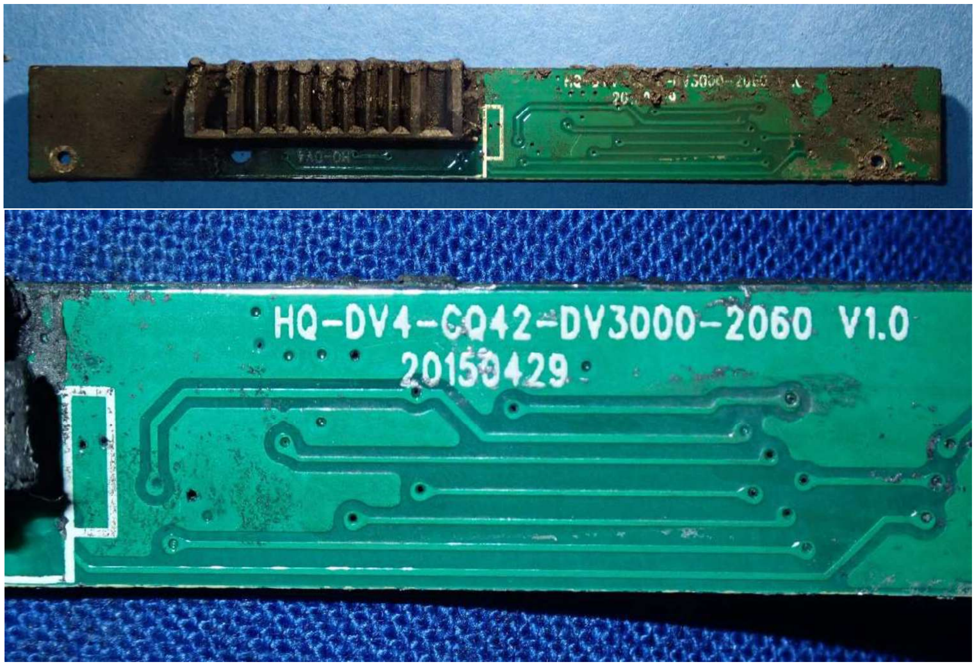

Figure 18. BMU labeling shown before (top) and after cleaning (bottom)

4.2.5 Other material not found at the lab exam

1. Ms. Marcellin testified in her deposition that there was a 1990's era Compaq computer in the closet in her office at the time of the fire, but that computer was not found at the scene and was not available for inspection at the laboratory examination.

2. Ms. Marcellin said that there was a computer in the closet in her office room at the time of the fire. There is no scientific basis to explain why the computer and its battery pack were not found if the computer was in the closet during the fire. There were no batteries or related materials found in the closet material that was examined at the scene. The temperatures of a fire do not cause materials such as copper and steel that are part of the computer to disintegrate. Therefore, the only logical possibilities are that the computer was removed after the fire or Ms. Marcellin is mistaken and it was not in the closet prior to the fire. Specific requests were made to produce the computer, yet it was never produced.

4.2.6 Summary

The BMU labeling indicates that the battery pack in the subject computer was not the one originally supplied by HPI. The battery pack lacked important safety features

1. The cell voltage measurements were only made from the ends of the cell stack. That is, they measured the voltage on the positive terminal of the most positive

cell position and the negative terminal of the most negative cell. Intermediate cell voltage measurements can detect cell deterioration as the cells age.

2. The battery cells are not the ones installed in the pack when it was made by HPI.

5.0 Battery Pack Origin

Ms. Marcellin testified that she never replaced the battery pack in the subject computer. But the subject pack has a 2015 date code which is at least 4 years after she purchased the computer and registered it for warranty purposes.

From the facts above, it is unclear as to how and when the subject pack was installed in the subject computer.

The cells are not the ones originally supplied by HPI with the HPI battery pack in the computer, and the BMU construction does not comply with HPI standards.

6.0 Review of plaintiff's report

I have read the report of plaintiff's expert Steve Martin. Dr. Martin agrees that the battery pack was not made by HPI. He contends that the HPI notebook should have included features that prevented the computer from working with a counterfeit battery pack. This feature is usually called authentication.

Dr. Martin says that the technology needed for authentication was available around the time the notebook was made and could have been used by HPI. He describes the following authentication features.

1. One simple authentication procedure is to have the computer ask the battery pack for a special code that identifies the pack and its manufacturer.

   The computer would not use the pack if the pack does not respond with correct code.

   This scheme can be defeated easily because would-be counterfeiters can monitor the communication between the computer and battery pack. This is sometimes called eavesdropping or sniffing. Would-be counterfeiters can record the pack identification information that is sent to the computer and then program that response into the BMU control circuit. This allows the BMU to make the battery pack appear to be a legitimate HPI pack. This defeats the authentication feature.

   The electrical engineering tools to "listen" and interpret the communication between the computer and pack are commercially available and easy to use. I have used one such

process myself and interpreted the computer/pack communication. These are tools that engineers would need to use to develop and test the proper operation of battery products.

2. A somewhat more sophisticated procedure makes use of an encryption feature that is sometimes built into the computer and BMU control chip. One such encryption feature is referred to as SHA-1, Secure Hash Algorithm-1. If the BMU chip encrypts the manufacturer code information then the would-be counterfeiter would not be able to simply listen for that code and use it directly, or at least that is the concept promoted by Dr. Martin.

   If the query and response are encrypted, it is still possible to defeat this scheme. The eavesdropping engineer only needs to know when in the startup sequence the communication codes occur. The question and answer do not need to be deciphered. Once the request and response are captured. The BMU can be programmed to recognize the request and respond with the encrypted response.

3. Dr. Martin also suggests that the encrypted codes can be designed to change each time the computer starts. This arrangement can be troublesome, since the battery pack might be moved from one computer to another. The pack might not be able to “pair” successfully with another computer because it would be “out of sync” from its previous use with the first computer, even though both might be legitimate HPI products.

4. The process of defeating authentication can be done using publicly available documents and commercially available electrical engineering tools.

   a. The publicly available documents describe the electrical signals on the battery connector that are used for the computer to communicate with the pack. There are 2 basic signals: a clock signal and a data signal. The rules for the use of the signals are described in the System Management Bus, or SMBus, The rules are defined in “the System Management Bus specification” which is published by the SBS implementers forum.
   b. The specific use of the SMBus with a battery pack is covered in the Smart Battery Data specification. That specification defines the codes on the bus and what they mean: such as a battery voltage or charging current.
   c. The tools for interpreting the SMBus signals on the battery connector include products such as signal analyzers made by Saleae and Beagle. These detect the signal on the bus and decode their meaning.

Dr. Martin also admits that more sophisticated authentication schemes can be used, but those are also subject to hacking. It just depends on how much work (and the related cost) needs to be used to defeat the authentication scheme.

I have personally tested 2010 vintage notebooks made by Apple, Dell and Lenovo using non-OEM counterfeit batteries. All 3 notebooks worked fine with the replacement batteries and did not provide any on-screen warnings about the presence of a non-OEM battery pack. This indicates that non-OEM battery warnings were not industry standard in the time frame in which the subject computer was manufactured. According to HP000481 the computer was manufactured in 2010.

Dr. Martin also suggested that the embedded controller in the notebook could have used a separate signal on pin 6 of the battery connector. The idea would be for the pack to provide a temperature measurement independent of the communication signals on the connector. The embedded controller would then stop charging the pack if that temperature signal were above a prescribed limit corresponding to 45 ˚C.

HPI has confirmed in answers to interrogatories that the subject computer had the function of responding to a temperature signal on pin 6 of the battery connector and to stop charging when the pack temperature signal indicated a temperature above 45 ˚C. Even though the notebook had the temperature sensing function, that function can be rendered inoperable by the simple addition of a fixed value resistor on the BMU instead of a thermistor. Such a resistor would always report an acceptable temperature measurement to the embedded controller in the notebook. An elevated battery temperature would never be detected. If the embedded controller is checking for that resistance to determine if there is really a pack connected it will be fooled into detecting a pack, even if it is a counterfeit pack without real temperature measurement.

Dr. Martin's report describes several methods that could have been used in the subject computer such that it would not have allowed a non-OEM battery pack to work. But his report presents theoretical arguments. He presumes that if HPI had implemented one of his suggested methods that it would have prevented the fire. But that conclusion assumes a fact that has not been established as evidence, which is that the non-OEM pack had not bypassed the authentication scheme or implemented the temperature measurement circuitry. Bypassing the authentication is a process that he admits is possible.

Dr. Martin has not done any engineering calculations, testing or measurements that prove one of his methods would actually have prevented the Marcellin fire.

7.0 Assessment

Dr. Martin has presented several arguments about authentication and temperature measurement functions that could have prevented the HPI computer from using a non-OEM battery pack. However, Dr. Martin agrees that the authentication schemes can be bypassed. In addition, Dr. Martin offers no information or references that authentication was in standard use by computer manufacturers in 2010, nor were such steps reasonably necessary.

Dr. Martin never performed any engineering tests with the products in question. As a result, Dr. Martin cannot verify that the subject battery pack was, or was not, able to bypass any of the authentication schemes he describes.

He also did not determine (by document or testing) if other computer manufacturers were using authentication schemes in the time period at issue in this case that could not easily be bypassed.

8.0 Conclusions

I have the following conclusions to a reasonable degree of engineering certainty based on my examination of the evidence, review of the documents, and my education, training and experience. I reserve the right to amend or modify this report as new information becomes available.

1. The battery pack in the subject computer at the time of the Marcellin fire was not an HPI battery pack, or an approved HPI product.
2. The battery pack in the subject computer was not the one that HPI provided with the computer. It bears a 2015 manufacturing date code which indicates it was made 5 years after the computer was manufactured.
3. Plaintiff's experts have not scientifically proven that an authentication scheme, if it had been installed when the notebook computer was made by HPI, would actually still be on the computer at the time of the Marcellin fire.
4. Authentication of the type hypothesized by Dr. Martin was not industry standard in 2010 and was not generally used by other manufacturers of notebook computers in 2010.
5. Even if authentication had been used it is more likely than not that it would have been defeated by the manufacturer of the subject battery pack by the time the subject battery pack was installed. Therefore, the fact that authentication was not used is not the cause of the Marcellin fire.
6. The thermal damage to the subject computer and the area around the computer is not consistent with a fire origin in the computer.
7. Plaintiff's expert Dr. Martin's opinion is based on untested theories with regard to the specific physical evidence in this case.
8. There is no scientific process that explains the missing Compaq computer and battery pack testified to by Ms. Marcellin. It would not have burned up to the point of complete disappearance in the fire,

Donald Galler, P.E.

Donald Galler

November 30, 2024